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(54) **IMPACT ROTATION TOOL**

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B25B 23/14 (2006.01)

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CPC ***B25B 21/02*** (2013.01); ***B25B 23/1405*** (2013.01)

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See application file for complete search history.

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(57) **ABSTRACT**

An impact rotation tool includes a drive source that generates power. An impact force generation unit generates impact force by changing the power generated by the drive source to pulsed torque. A shaft transmits the pulsed torque to the distal tool with the generated impact force. A torque detector generates a signal corresponding to the torque applied to the shaft. A determination unit determines whether or not a torque value obtained from a signal corresponding to the torque has reached a predetermined torque value. A control unit controls the drive source to a predetermined driving state when the determination unit determines that the torque value has reached the predetermined torque value. The determination unit is arranged on the shaft.

12 Claims, 8 Drawing Sheets

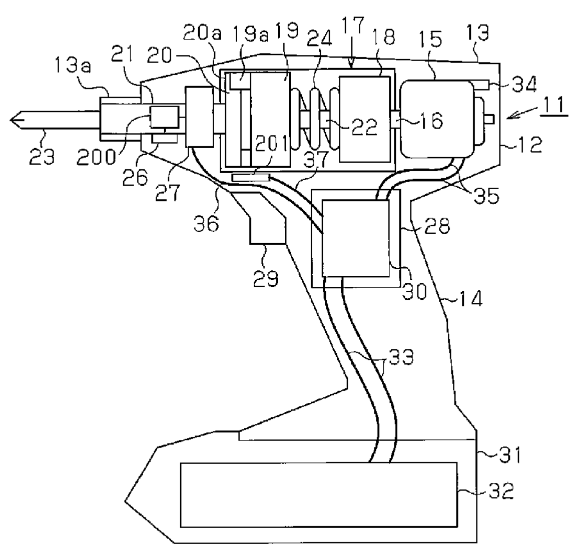

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Fig.1

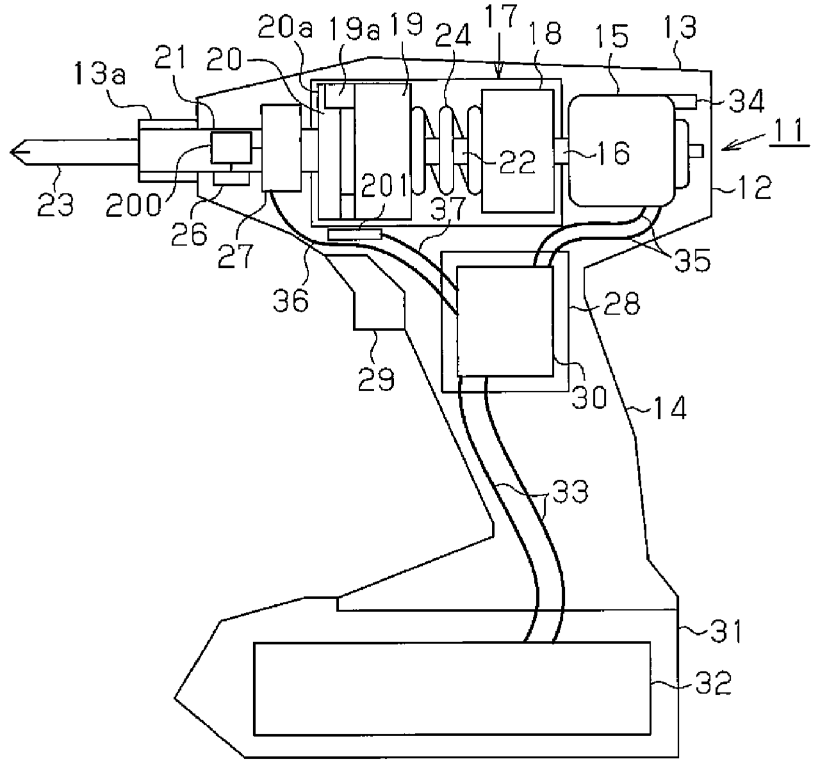


Fig.2A

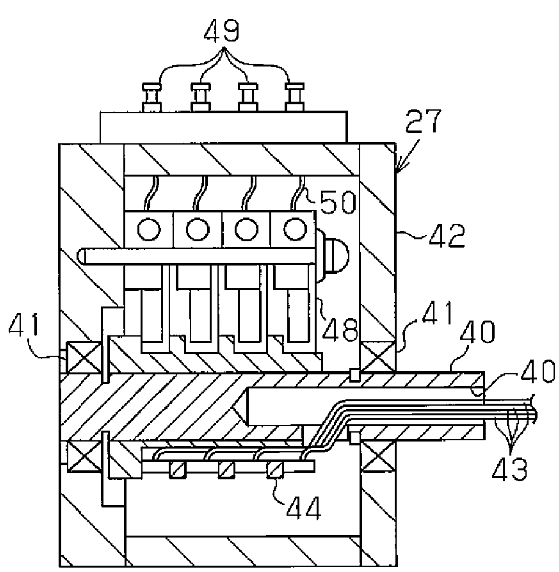


Fig.2B

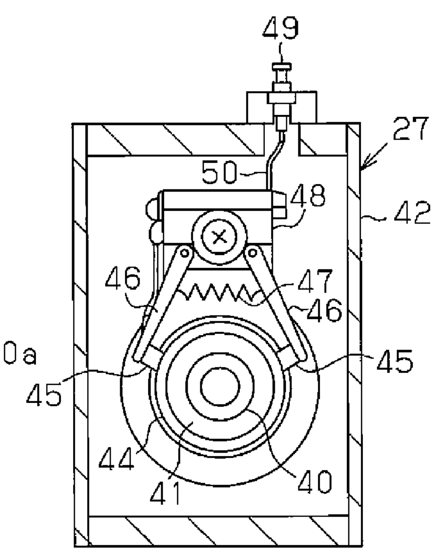


Fig.3

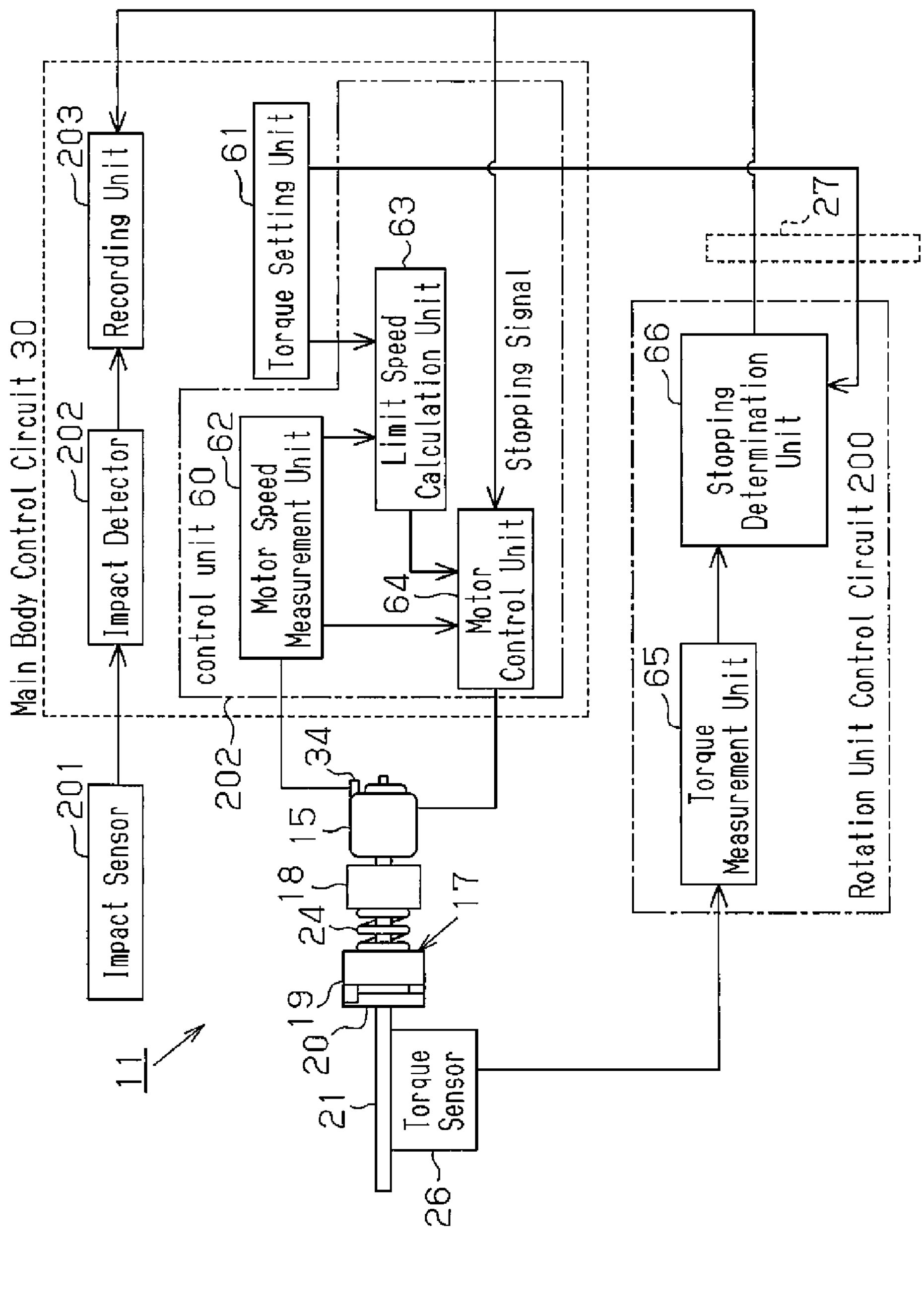

Main Body Control Circuit 30
Impact Sensor
201
Impact Detector
202
Recording Unit
203
Torque Setting Unit
61
Limit Speed Calculation Unit
63
control unit 60
Motor Speed Measurement Unit
62
Motor Control Unit
64
Stopping Signal
Stopping Determination Unit
66
Torque Measurement Unit
65
Rotation Unit Control Circuit 200
27
Torque Sensor
26
11
202
34
15
18
24
17
19
20
21

Fig.4

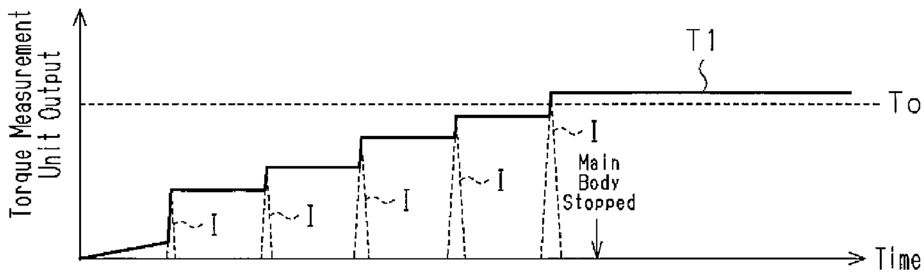


Fig.5

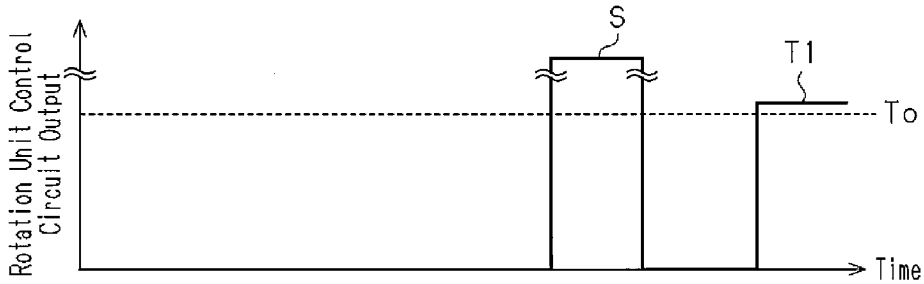


Fig.6

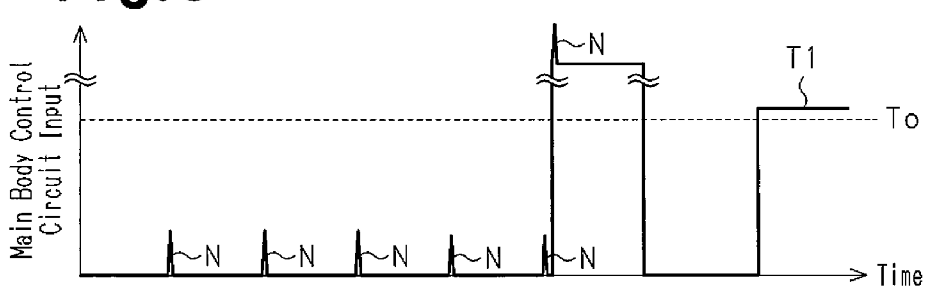


Fig.7

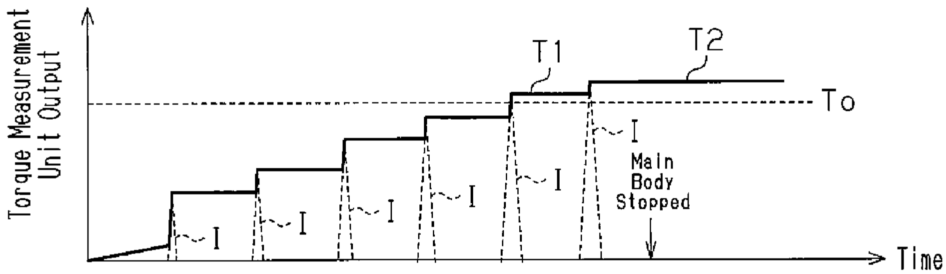


Fig.8

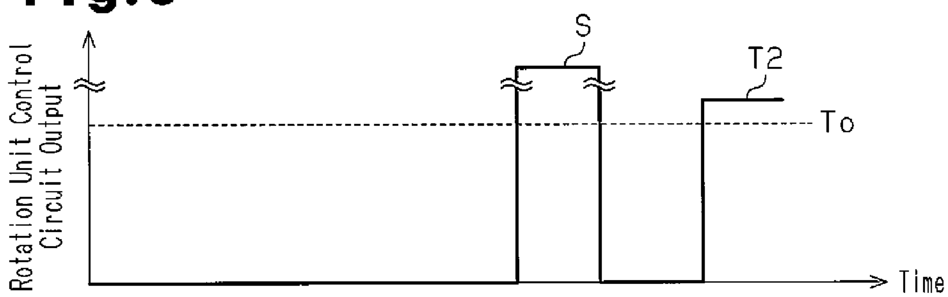


Fig.9

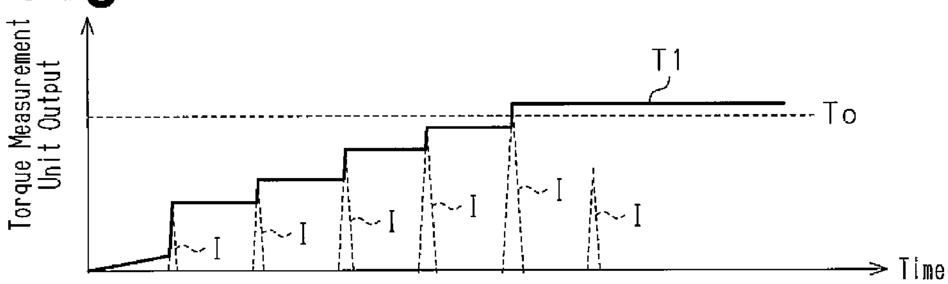


Fig.10

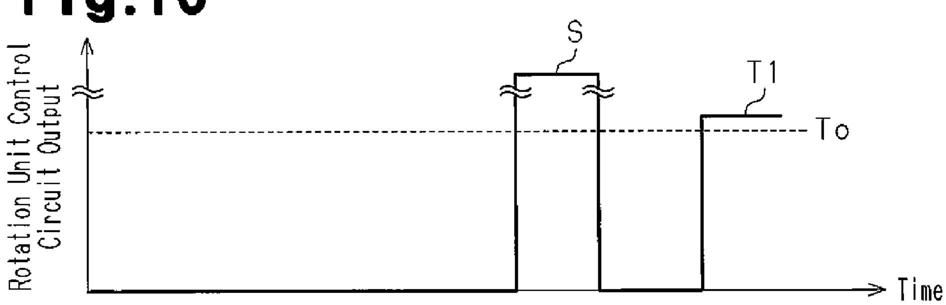


Fig.11

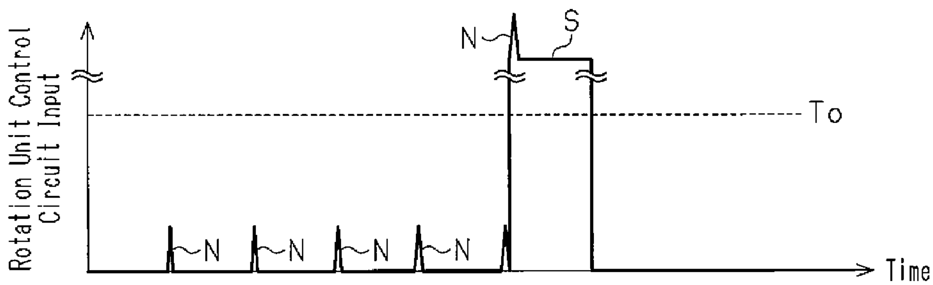


Fig.12

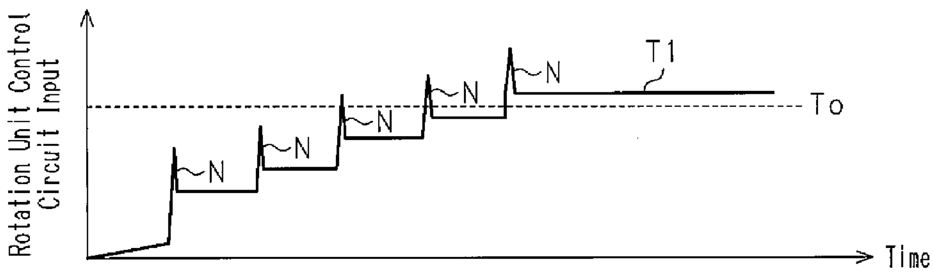


Fig.13

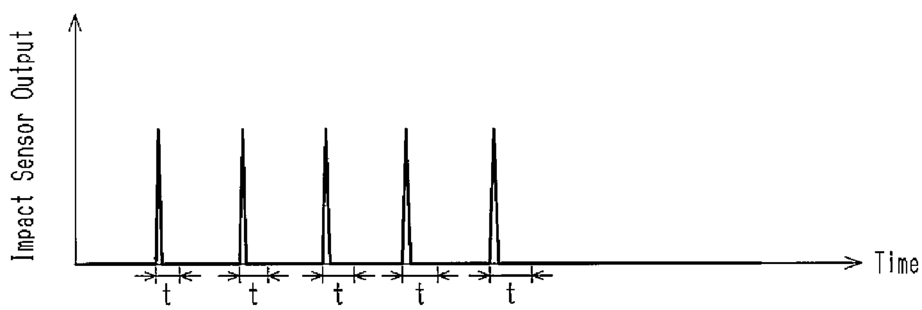


Fig.14

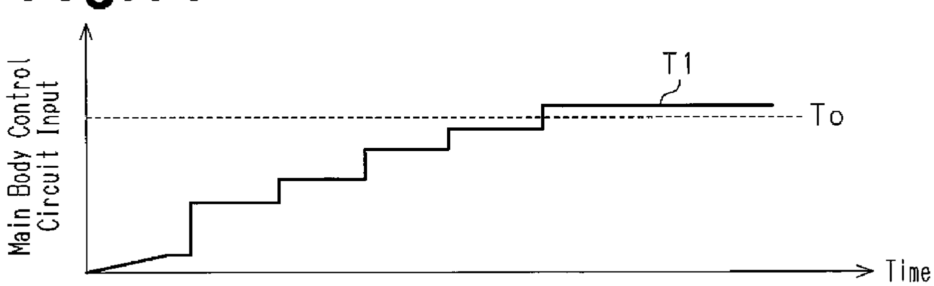


Fig.15

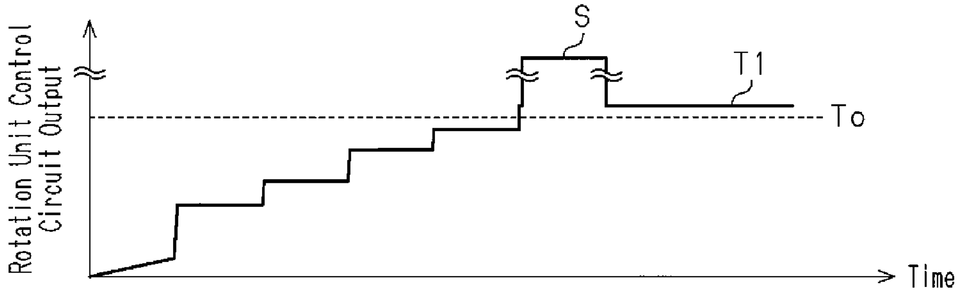

Rotation Unit Control
Circuit Output
S
T1
To
Time

Fig.16

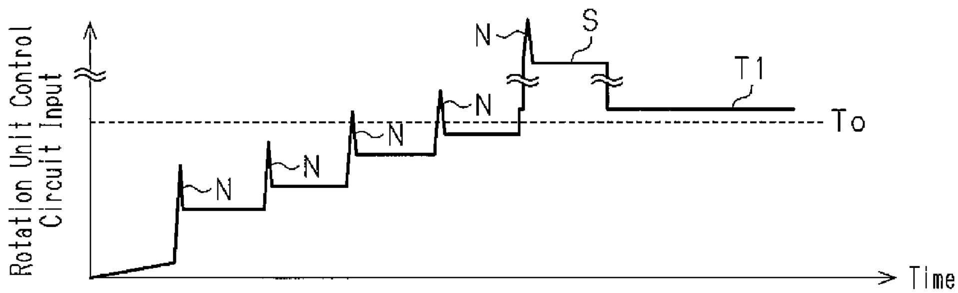

Rotation Unit Control
Circuit Input
N
S
T1
To
N
N
N
N
Time

Fig.17B

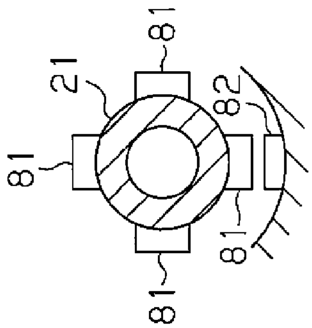


Fig.17A

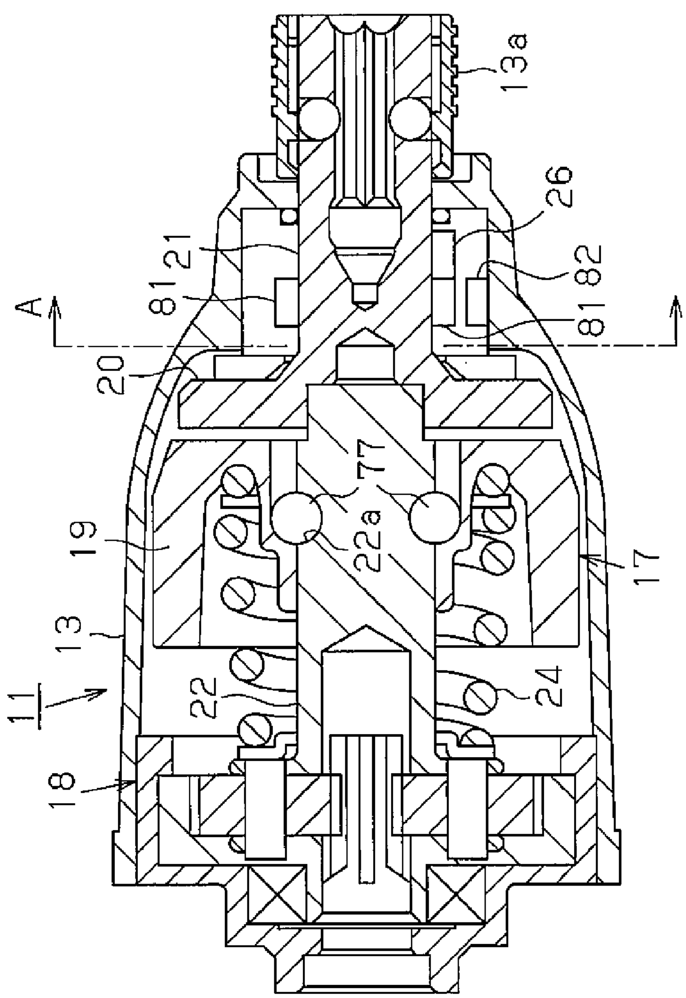


Fig.18

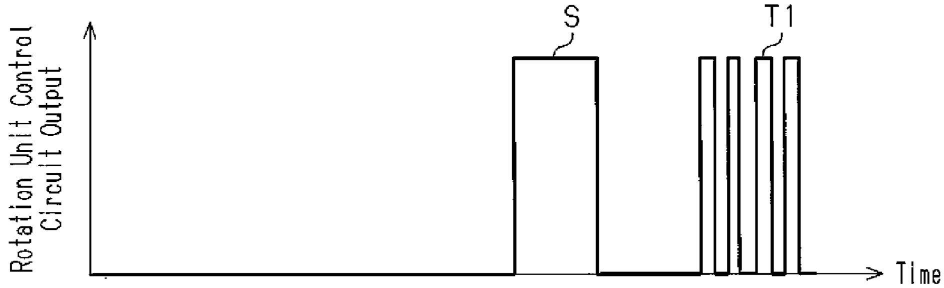


Fig.19A

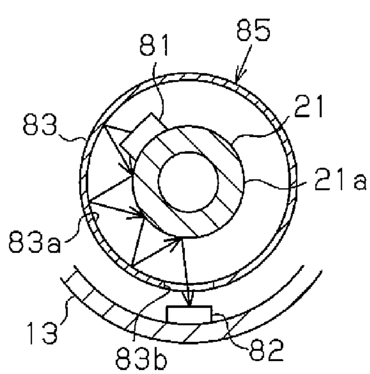
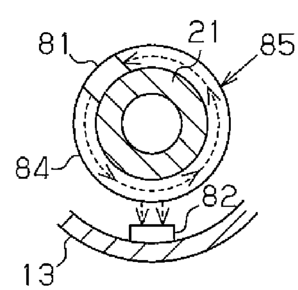


Fig.19B



IMPACT ROTATION TOOL

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based upon and claims the benefit of priority from prior Japanese Patent Application No. 2012-227185, filed on Oct. 12, 2012, the entire contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

The present invention relates to an impact rotation tool including an impact force generation unit that converts the power of a drive source to impact force, which is pulsed torque, and uses the impact force to rotate a shaft, to which a tip tool is coupled.

An impact rotation tool decelerates the rotation output of a motor, which is one example of a drive source, with a deceleration mechanism, uses hydraulic pressure or the striking action of a hammer to convert the decelerated rotation output to pulsed impact torque, and performs a tightening task or a loosening task with the impact torque. Impact rotation tools are often used in construction sites and assembly factories (for example, refer to Japanese Laid-Open Utility Model No. 1-106169 and Japanese Laid-Open Patent Publication Nos. 1-106169, 8-267368, 2010-12587, and 11-267981).

When using an impact rotation tool, a fastener such as a bolt or screw, may be over-tightened by a large torque. On the other hand, when attempting to avoid such over-tightening, a fastener may be inefficiently tightened thus causing the fastener to be fixed with strength that is lower than necessary. Accordingly, Japanese Laid-Open Utility Model No. 1-106169 and Japanese Laid-Open Patent Publication No. 8-267368 each describe an impact rotation tool that measures torque with a strain gauge, a torque sensor, or the like, which is arranged on a shaft, so that a fastener can be tightened with a predetermined torque. When the torque indicated by the output value of the sensor reaches a predetermined torque such as a target torque, the motor is stopped.

In this case, the shaft on which the sensor is arranged is a drive portion. Thus, the sensor output value has a tendency of containing noise. This hinders accurate torque measurement. In particular, a relatively large noise is easily generated in an impact rotation tool when an impact force is applied to the shaft. As a result, in the sensor output, it is difficult to distinguish impact pulses from noise. As a result, when noise is erroneously detected as torque and the detected torque affected by noise reaches the predetermined torque, the motor may be controlled in a predetermined driving state and thereby be stopped. In such a case, the impact rotation tool stops before the tightening torque reaches the predetermined torque. To cope with this problem, Japanese Laid-Open Patent Publication No. 11-267981 describes an impact rotation tool that includes a filtering means such as low-pass filter to remove noise from the sensor output of a strain gauge, which is arranged on a drive shaft of a pulse wrench.

However, the filtering means of Japanese Laid-Open Patent Publication No. 11-267981 results in the impact rotation tool having a complicated structure. This increases the manufacturing cost of the impact rotation tool. It is difficult to set the cutoff frequency of the filtering means that distinguishes impact pulses from noise and removes only noise. For example, in an impact wrench, which is one type

of an impact rotation tool, changes in the torque are more sudden than the pulse wrench of Japanese Laid-Open Patent Publication No. 11-267981. Thus, it is further difficult to distinguish impact pulses from noise.

SUMMARY OF THE INVENTION

One aspect of the present invention is an impact rotation tool including a drive source that generates power. An impact force generation unit generates impact force by changing the power generated by the drive source to pulsed torque. A shaft transmits the pulsed torque to the distal tool with the generated impact force. A torque detector generates a signal corresponding to the torque applied to the shaft. A determination unit determines whether or not a torque value obtained from a signal corresponding to the torque has reached a predetermined torque value. A control unit controls the drive source to a predetermined driving state when the determination unit determines that the torque value has reached the predetermined torque value. The determination unit is arranged on the shaft.

Other aspects and advantages of the present invention will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention, together with objects and advantages thereof, may best be understood by reference to the following description of the presently preferred embodiments together with the accompanying drawings in which:

FIG. **1** is a schematic cross-sectional view showing a first embodiment of an impact rotation tool;

FIG. **2**A is a cross-sectional view of a slip ring unit;

FIG. **2**B is a front view of the slip ring unit;

FIG. **3** is an electric block diagram of the impact rotation tool;

FIG. **4** is a graph showing the waveform of a voltage signal output from a torque measurement unit

FIG. **5** is a graph showing the waveform of a voltage signal output from a rotation unit control circuit;

FIG. **6** is a graph showing the waveform of a voltage signal input to a main body control circuit and containing noise produced by an impact;

FIG. **7** is a graph showing the waveform of a voltage signal output from the torque measurement unit in a second embodiment when the torque is increased by an impact after a stopping signal is output;

FIG. **8** is a graph showing the waveform of a voltage signal output from a rotation unit control circuit in the second embodiment when the torque is increased by an impact after a stopping signal is output;

FIG. **9** is a graph showing the waveform of a voltage signal output from the torque measurement unit in the second embodiment when the torque is not increased by an impact after a stopping signal is output;

FIG. **10** is a graph showing the waveform of a voltage signal output from the rotation unit control circuit in the second embodiment when the torque is not increased by an impact after a stopping signal is output;

FIG. **11** is a graph showing the waveform of a voltage signal output from a rotation unit control circuit in a third embodiment;

FIG. **12** is a graph showing the waveform of a voltage signal input to a main body control circuit when the noise produced by an impact is removed;

FIG. **13** is a graph showing the waveform of a voltage signal output from an impact sensor in a fourth embodiment;

FIG. **14** is a graph showing the waveform of a voltage signal input to a main body control unit when the noise produced by an impact is removed;

FIG. **15** is a graph showing the waveform of a voltage signal output from a rotation unit control circuit in a fifth embodiment;

FIG. **16** is a graph showing the waveform of a voltage signal input to a main body control unit and containing noise produced by an impact;

FIG. **17**A is a partial cross-sectional view showing a sixth embodiment of an impact rotation tool;

FIG. **17**B is a cross-sectional view taken along line A-A in FIG. **17**A;

FIG. **18** is a graph showing the waveform of a voltage signal output from a rotation unit control circuit in the sixth embodiment; and

FIGS. **19**A and **19**B are schematic cross-sectional views showing modifications of a light transmission unit.

DETAILED DESCRIPTION OF THE INVENTION

First Embodiment

A first embodiment of an impact rotation tool will now be described with reference to FIGS. **1** to **6**.

FIG. **1** shows an impact rotation tool **11** that is of a hand-held type and held by a single hand. The impact rotation tool **11** may be, for example, an impact driver or an impact wrench. A main body housing **12**, which forms the casing of the impact rotation tool **11**, includes a barrel **13** and a handle **14**, which extends from the barrel **13**. The handle **14** extends downward, as viewed in FIG. **1**, in a direction intersecting the axis of the barrel **13**.

A motor **15** is arranged in the barrel **13** at a basal side, which is the right side as viewed in FIG. **1**. The axis of the motor **15** lies along the axis of the barrel **13**. The motor **15** includes an output shaft **16** that faces toward a distal side of the barrel **13**. The motor **15** is a DC motor and may be a brushed motor or a brushless motor. An impact force generation unit **17** is coupled to the output shaft **16** of the motor **15**. The impact force generation unit **17** generates impact force by converting the rotation power produced by the motor **15** to pulsed torque.

The impact force generation unit **17** includes a deceleration mechanism **18**, a hammer **19**, an anvil **20**, and a main shaft **21**, which are sequentially arranged from the motor **15**. The main shaft **21** is one example of a shaft. The deceleration mechanism **18** decelerates the rotation output of the motor **15** by a predetermined speed reduction ratio and increases the torque of the rotation. Then, the deceleration mechanism **18** transmits the decelerated and torque-increased rotation to the hammer **19**, which strikes the anvil **20**. The striking action of the hammer **19** applies the rotational force as an impact to the main shaft **21**. The main shaft **21** may be formed integrally with the anvil **20** as a portion of the anvil **20**. Alternately, the main shaft **21** may be formed discretely from the anvil **20** and be fixed to the anvil **20**.

The hammer **19** is coupled to a drive shaft **22**, which is rotated by the output of the deceleration mechanism **18**. The hammer **19** is rotatable relative to the drive shaft **22** and movable toward the front and rear along the drive shaft **22**. A coil spring **24** is arranged between the deceleration mechanism **18** and the hammer **19**. The elastic force of the coil spring **24** urges the hammer **19** toward the front side, which is the left side as viewed in FIG. **1**, to where the hammer **19** abuts against the anvil **20**. Two abutment portions **19***a*, which extend from the hammer **19** toward the anvil **20**, are arranged on the hammer **19** at equal intervals in the circumferential direction. Each abutment portion **19***a* abuts against an abutment portion **20***a*, which extends in the radial direction of the anvil **20**. The abutment of the abutment portions **19***a* against the abutment portions **20***a* integrally rotate the hammer **19** and the anvil **20**. This transmits the rotation of the drive shaft **22**, decelerated by the deceleration mechanism **18**, to the main shaft **21**, which is coaxial with the anvil **20**. The barrel **13** has a distal end, which is the right end as viewed in FIG. **1**. A chuck **13***a* is arranged on the distal end of the barrel **13**. The chuck **13***a* includes a socket that receives a distal tool **23**. The distal tool **23** is removable from the chuck **13***a*.

When the rotation of the distal tool **23** tightens a fastener such as a bolt or a screw to a certain extent, the load applied to the main shaft **21** is larger than that applied, for example, when the tightening of the fastener starts. On the other hand, when the rotation of the distal tool **23** loosens a fastener to a certain extent, the load applied to the main shaft **21** is smaller than that applied, for example, when the loosening of the fastener starts. When a force larger than or equal to a predetermined level is applied between the hammer **19** and the anvil **20**, the hammer **19** moves toward the rear, or rightward as viewed in FIG. **1**, along the drive shaft **22** while compressing the coil spring **24**. When the hammer **19** is rotated relative to the anvil **20** by a certain amount or greater, the compression force of the coil spring **24** is released. As a result, the urging force of the coil spring **24** causes the hammer **19** to strike the anvil **20** while rotating the hammer **19**. Whenever the hammer **19** is rotated by a certain amount or greater relative to the anvil **20** by the load applied to the main shaft **21**, the striking action of the hammer **19** is repeated. When the hammer **19** strikes the anvil **20** in this manner, an impact is applied to the fastener.

As shown in FIG. **1**, a torque sensor **26**, which is one example of a torque detector, and a rotation unit control circuit **200**, are arranged on the main shaft **21** of the impact rotation tool **11**. Further, a slip ring unit **27** is coupled to the main shaft **21** to transfer the output of the rotation unit control circuit **200** from the main shaft **21**, which serves as a rotating system, to the wiring of the main body housing **12**, which serves as a stationary system. The slip ring unit **27** is used for the output transfer between the main shaft **21** and the main body housing **12**. This suppresses the twisting of wires and the entangling of wires to the main shaft **21**.

The torque sensor **26** is a strain sensor capable of detecting torsional strain and adhered by an adhesive agent to the main shaft **21**. The torque sensor **26** is connected to the rotation unit control circuit **200** to detect the strain produced in the main shaft **21** when torque is applied and generate a voltage signal that is proportional to the strain. The voltage signal generated by the torque sensor **26** is a torque detection signal corresponding to the torque, and the torque detection signal is provided from the torque sensor **26** to the rotation unit control circuit **200**, which is arranged on the main shaft **21**.

The rotation unit control circuit **200** receives the voltage signal from the torque sensor **26** and uses the received voltage signal to compute the torque acting on the main shaft **21** as a torque value. The rotation unit control circuit **200** generates a stopping signal in addition to the torque value, which is the computation result of the torque. The rotation unit control circuit **200** provides the torque value and the stopping signal via the slip ring unit **27** to a circuit substrate **28** of the main body housing **12**. A main body control circuit **30**, which controls the rotation and sets the torque for the motor **15**, is arranged on the circuit substrate **28**, which is arranged in the handle **14**.

The main body housing **12** is a non-rotation portion that is not rotated by the rotation of the main shaft **21**. An impact sensor **201** is coupled to the main body housing **12** in the vicinity of the hammer **19** to detect the impact produced by the hammer **19**. An acceleration sensor that generates electric charge when stress is applied may be used as the impact sensor **201**. Further, a microphone that detects the noise produced when the hammer **19** strikes the anvil **20** and generates a detection signal accordingly may be used as the impact sensor **201**.

The handle **14** includes a trigger lever **29** operated by a user to drive the impact rotation tool **11**. A battery pack holder **31**, which is box-shaped, is attached in a removable manner to the lower end of the handle **14**. The battery pack holder **31** accommodates a battery pack **32**, which is a rechargeable battery. The impact rotation tool **11** is of a chargeable type that uses the battery pack **32** as a power source. The battery pack **32** is connected by power lines **33** to the main body control circuit **30**.

A speed detector **34** is arranged on the motor **15** to detect the rotation speed of the motor **15**. The speed detector **34** forms a rotation speed output unit and may be embodied in, for example, a frequency generator that generates a frequency signal having a frequency that is proportional to the rotation speed of the motor **15**. The rotation speed detector **34** may be, for example, an encoder. When the motor **15** is of a brushless type, the speed detector **34** may be a Hall sensor, and the rotation speed may be obtained from the signal or back electromotive force of the Hall sensor. The speed detector **34** provides the main body control circuit **30** with a signal corresponding to the rotation speed.

Lead lines **35** electrically connect the main body control circuit **30** to the motor **15** to control and drive the motor **15**. Further, signal lines **36** electrically connect the main body control circuit **30** to the rotation unit control circuit **200** via the slip ring unit **27**. The signal lines **36** include four conductive lines, namely, a signal line that provides signals from the rotation unit control circuit **200** to the main body control circuit **30**, a power line that supplies the rotation unit control circuit **200** with power, a signal line that provides the rotation unit control circuit **200** with a set torque value, and a ground line. FIG. **1** shows only one of the signal lines **36** to facilitate illustration. In this manner, the slip ring unit **27** is used to provide signals from the rotation unit control circuit **200** to the main body control circuit **30** and provide the set torque value from the main body control circuit **30** to the rotation unit control circuit **200**. Further, a signal line **37** is connected to the main body control circuit **30** to provide a signal from the impact sensor **201** to the main body control circuit **30**. A trigger switch, which is electrically connected to the main body control circuit **30**, detects the operation of the trigger lever **29**.

When the user is operating the trigger lever **29**, the main body control circuit **30** executes a control for varying the rotation speed of the motor **15** in accordance with the pulled amount of the trigger lever **29**. The main body control circuit **30** controls the amount of current flowing to the motor **15** with a motor driver to control the rotation produced by the motor **15** and set the torque of the motor **15**. The rotation unit control circuit **200** receives a torque detection signal corresponding to the strain of the main shaft **21** detected by the torque sensor **26** and generates a stopping signal or the like when the computed torque value exceeds the set torque value.

The structure of the slip ring unit **27** will now be described with reference to FIGS. **2**A and **2**B.

As shown in FIGS. **2**A and **2**B, the slip ring unit **27** includes a case **42** provided with bearings **41** to rotatably support a rotation shaft **40**, which forms the main shaft **21**. Signal lines **43** extend from the torque sensor **26** via the rotation unit control circuit **200** toward the slip ring unit **27**. The signal lines **43** extend through a wire conduit **40***a* and are connected to slip rings **44** in the case **42**. For example, each of the four signal lines **43** extending from the torque sensor **26** is connected to a corresponding one of the slip rings **44**. The case **42** includes four slip rings **44**. The slip rings **44** are fixed to the outer surface of the rotation shaft **40**.

As shown in FIG. **2**B, the case **42** accommodates a terminal box **48** that pivotally supports basal portions of two arms **46**. Each arm **46** includes a distal portion coupled to a brush **45**. A spring **47** is coupled between the two arms **46** to urge the arms **46** toward each other. The urging force of the spring **47** forces the two brushes **45** against the outer surface of the corresponding slip ring **44**.

The torque detection signal transmitted through each signal line **43** is provided to the terminal box **48** through a transmission line formed by the corresponding slip ring **44** and the corresponding pair of brushes **45**. The signal provided to the terminal box **48** is sent to terminals **49**, which are fixed to the outer upper side of the case **42**, via signal lines **50**. Each terminal **49** is connected to one of the signal lines **36** connected to the main body control circuit. The output of the rotation unit control circuit **200** is provided to the main body control circuit **30** as the slip rings **44** and the brushes **45** come into contact and move relative to each other in the slip ring unit **27**. The set torque value provided from the main body control circuit **30** is provided to the rotation unit control circuit **200** as the slip rings **44** and the brushes **45** come into contact and move relative to each other in the slip ring unit **27**.

The electrical configuration of the impact rotation tool **11** will now be discussed with reference to FIG. **3**.

As shown in FIG. **3**, the impact rotation tool **11** includes the torque sensor **26**, the rotation unit control circuit **200**, which receives a signal from the torque sensor **26**, and the main body control circuit **30**, which receives the output of the rotation unit control circuit **200** via the slip ring unit **27**. The main body control circuit **30** includes a control unit **60**, which manages torque and controls the speed of the motor **15**, and a torque setting unit **61**, which sets the set torque value used as a tightening torque target value. Further, the main body control circuit **30** includes a recording unit **203** that records the output of the rotation unit control circuit **200**.

The torque setting unit **61**, which is formed by, for example, a variable resistor or the like, is electrically connected to the control unit **60** and the rotation unit control circuit **200**. The set torque for stopping the motor **15** is set when the user operates the torque setting unit **61**. The torque setting unit **61** sets a target torque To within a range of ±10% of the set torque. The torque setting unit **61** may be configured to set the set torque as the target torque To. In the present embodiment, the target torque To corresponds to one example of a predetermined torque value.

The control unit **60** includes a motor speed measurement unit **62**, which measures the rotation speed of the motor **15**, the limit speed calculation unit **63**, which calculates a limit speed, and a motor control unit **64**, which drives and controls the motor **15**. The main body control circuit **30** includes a CPU. The control unit **60** may be configured by software that has the CPU execute a control program to configure the units **62** to **64**. Alternatively, the control unit **60** may be configured by hardware that forms the units **62** to **64** with integrated circuits such as ASICs. As another option, some of the units **62** to **64** may be configured by software, and the other units may be configured by hardware.

The motor speed measurement unit **62** measures the rotation speed of the motor **15** based on a signal corresponding to the speed provided from the speed detector **34**. The limit speed calculation unit **63** receives the measured rotation speed of the motor **15** and the target torque To and calculates the limit rotation speed of the motor **15** when the trigger lever **29** is pulled in accordance with the level of the target torque To. The motor control unit **64** controls and drives the motor **15** so that the rotation speed of the motor **15** is limited to be less than or equal to the limit speed. When the target torque To is small, even if the trigger lever **29** is pulled by the maximum amount, the motor control unit **64** limits the motor **15** to a speed that is less than the maximum speed. The main body control circuit **30** also includes an impact detector **202** that receives a signal from the impact sensor **201**, which detects impacts.

The rotation unit control circuit **200** includes a torque measurement unit **65**, which measures the value of the torque applied to the main shaft **21** based on the detection signal of the torque sensor **26**, and a stopping determination unit **66**, which is one example of a determination unit that determines whether or not the torque value has reached the target torque. The torque measurement unit **65** obtains, for example, a peak value in the torque detection signal output from the torque sensor **26** as the torque value. The torque measurement unit **65** provides the obtained torque value to the stopping determination unit **66**. The rotation unit control circuit **200** includes a CPU. The torque measurement unit **65** and the stopping determination unit **66** may be configured by software by having the CPU execute a torque detection program and a determination program. Alternatively, the torque measurement unit **65** and the stopping determination unit **66** may be configured by hardware including integrated circuits such as ASICs. As another option, one of the units **65** and **66** may be configured by software, and the other unit may be configured by hardware.

The operation of the impact rotation tool **11** in the present embodiment will now be described. For example, when a user tightens a bolt or a screw, the torque setting unit **61** is operated in advance to set the set torque. Then, when the user operates the trigger lever **29**, the impact rotation tool **11** is driven. This rotates the distal tool **23** and tightens the bolt or screw.

When the impact rotation tool **11** is driven, the deceleration mechanism **18** decelerates the rotation output of the motor **15**. This increases the torque of the rotation output. The rotation output is then transmitted via the impact force generation unit **17** to the main shaft **21** to rotate the distal tool **23** coupled to the distal end of the main shaft **21**.

When a force that is larger than or equal to a predetermined level is produced between the hammer **19** and the anvil **20**, the hammer **19** rotates relative to the anvil **20** and moves toward the rear along the drive shaft **22** against the urging force of the coil spring **24**. This moves the hammer **19** away from the anvil. Then, due to the elastic force of the compressed coil spring **24**, the hammer **19** strikes the anvil **20**.

Referring to FIGS. **4** to **6**, the determination process performed by the stopping determination unit **66** will now be discussed. A case in which the fastener tightened by the impact rotation tool **11** is a screw will be described. In FIG. **4**, the solid line shows the torque value generated by the torque measurement unit **65**, and the broken line shows the impact pulse formed for each impact in the waveform of the voltage signal generated by the torque sensor **26**. FIG. **5** shows the waveform of the voltage signal generated by the rotation unit control circuit **200**, and FIG. **6** shows the waveform of the voltage signal received by the main body control circuit **30**.

As shown in FIG. **5**, the hammer **19** does not strike the anvil **20** immediately after the impact rotation tool **11** starts tightening the screw. Thus, the torque value measured by the torque measurement unit **65** gradually increases as the screw tightens. When the torque exceeds a certain value and the hammer **19** strikes the anvil **20**, the peak value in the output waveform of the torque sensor **26**, that is, the peak value for each impact pulse I, is held as the torque value. The peak values of the impact pulse I gradually increase as the screw tightens. Thus, the torque value measured by the torque measurement unit **65** is updated in a stepped manner whenever an impact pulse I is generated.

Depending on the type of the impact rotation tool, the peak value in the waveform of the voltage signal generated by the torque sensor **26** may be difficult to detect, and the correlation may be low between the peak value in the waveform of the voltage signal and the actual torque. In such a case, the torque value may be estimated from a parameter having a greater correlation with the torque than the peak value such as the area of the waveform of the voltage signal generated by a single impact, that is, the area of a single impact pulse. The torque value may be estimated using a predetermined computation equation or a table prepared in advance.

When the torque value becomes torque value T**1** and exceeds the target torque To, the stopping determination unit **66** provides the motor control unit **64** and the recording unit **203** with a stopping signal S that instructs the motor control unit **64** and the recording unit **203** to stop driving the motor **15**. When the error between the target torque To and the torque value becomes less than or equal to a certain ratio even though the torque value does not exceed the target torque value, the stopping determination unit **66** provides the motor control unit **64** and the recording unit **203** with a stopping signal S that stops driving the motor **15**. When the motor control unit **64** receives the stopping signal S from the stopping determination unit **66**, the motor **15** stops operating. As a result, when the tightening torque reaches the target torque To, the impact rotation tool **11** stops operating.

The torque value measured by the torque measurement unit **65** as shown in FIG. **4** may be provided to the main body control circuit **30**, which determines to stop the motor **15**. In such a case, the torque measurement unit **65** provides the torque value to the main body control circuit **30** via the slip ring unit **27**. Thus, when an impact pulse I is generated, the two brushes **45** of each slip ring unit **27** vibrate and produce noise N mixed in the output value of the slip ring unit **27**. As a result, due the noise N generated from the slip ring unit **27**, the difference between the target torque To and the output value of the slip ring unit **27** becomes greater than the difference between the target torque To and torque value of the torque measurement unit **65**. This lowers the accuracy of the stopping determination.

In this regard, the present embodiment determines to stop the motor **15** with the rotation unit control circuit **200** arranged in the main shaft **21**. Thus, the torque value that is free from the noise N from the slip ring unit **27** is compared with the target torque To. This increases the accuracy of the stopping determination for the motor **15**.

Referring to FIG. **5**, the rotation unit control circuit **200** of the present embodiment provides the main body control circuit **30** with a stopping signal S. The stopping signal S is an ON/OFF signal.

As shown in FIG. **6**, when the stopping signal S is provided from the rotation unit control circuit **200** to the main body control circuit **30** via the slip ring unit **27**, the signal output from the slip ring unit **27** includes noise. However, the noise N included in the signal output from the slip ring unit **27** is of a level that does not affect the input of the stopping signal S at the main body control circuit **30**. Thus, when the stopping determination unit **66** generates the stopping signal S, that is, when the torque applied to the main shaft **21** reaches the target torque To, the motor **15** may be stopped.

After receiving the stopping signal S, the main body control circuit **30** may provide the stopping determination unit **66** with an instruction via a signal line to send the final torque value to the recording unit **203**. In this case, the motor control unit **64** includes a rotation speed threshold set to obtain the final torque value, and compares the rotation speed provided from the motor speed measurement unit **62** with a threshold. When the rotation speed becomes equal to or less than a threshold, the motor control unit **64** provides the stopping determination unit **66** with an instruction to obtain the final torque value. The stopping determination unit **66** receives a command from the motor control unit **64** and provides the recording unit **203** with the final torque value T**1** received from the torque measurement unit **65**.

When the final torque value T**1** is generated in this manner, the motor **15** and the output shaft **16** stop rotating. Thus, the output waveform provided from the rotation unit control circuit **200** via the slip ring unit **27** to the main body control circuit **30** does not include noise N produced when the hammer **19** strikes the anvil **20**. Consequently, the recording unit **203** is provided with the torque value required for tightening that is more accurate than when the final torque value T**1** is generated when the impact rotation tool **11** is operating, that is, when the motor **15** and the output shaft **16** is rotating. Whenever the user performs a tightening task, the recording unit **203** records the torque value and the time required for the tightening. This allows for the user to obtain the torque value and time for each task after the tasks are completed.

The impact rotation tool of the present embodiment has the advantages described below.

(1) The rotation unit control circuit **200**, which includes the stopping determination unit **66**, is arranged on the main shaft **21**. Thus, the torque value compared to the target torque value does not include noise N produced from the slip ring unit **27**. Consequently, the accuracy of the comparison result of the target torque value and the torque value is increased and the accuracy of the determination for stopping the motor **15** is increased as compared with a structure that arranges a control circuit including the stopping determination unit **66** in the main body housing **12**. This reduces cases in which the motor **15** is controlled to a predetermined driving state before the torque reaches the predetermined torque due to erroneous torque detection caused by noise that is generated by an impact.

(2) When the motor **15** stops rotating, the rotation unit control circuit **200** provides the main body control circuit **30** with a final torque value after the output shaft **16** stops rotating. Thus, the main body control circuit **30** is provided with a further accurate final torque value compared to a structure that provides the main body control circuit **30** with the final torque value when the motor **15** and the output shaft **16** are still rotating.

(3) The slip ring unit **27** electrically connects the rotation unit control circuit **200** and the main body control circuit **30**. Thus, the wires connecting the control circuit **200** and the main body control circuit **30** do not become twisted or entangled with the main shaft **21** during rotation of the main shaft **21**.

Second Embodiment

A second embodiment of an impact rotation tool will now be described with reference to FIGS. **7** to **10**. The impact rotation tool of the second embodiment differs from that of the first embodiment in how the output shaft **16** is rotated after the stopping signal S is provided from the stopping determination unit **66**. The difference will now be described in detail.

As described above, the motor control unit **64** that receives the stopping signal S from the stopping determination unit **66** stops driving the motor **15**. In this case, the hammer **19** may strike the anvil **20** until the output shaft **16** stops rotating. When the hammer **19** strikes the anvil **20** before the output shaft **16** stops rotating, the impact pulse I after the stopping determination unit **66** generates the stopping signal S may differ from the impact pulse I immediately before the stopping determination unit **66** generates the stopping signal S.

Referring to FIG. **7**, when the hammer **19** strikes the anvil **20** before the output shaft **16** stops rotating, the impact pulse I after the stopping determination unit **66** generates the stopping signal S may be larger than the impact pulse I immediately before the stopping determination unit **66** generates the stopping signal S. In such a case, the final torque value that is the torque value when the output shaft **16** of the motor **15** stops is varied from torque value T**1** to torque value T**2**.

Referring to FIG. **8**, when the final torque value is varied from torque value T**1** to torque value T**2**, the stopping determination unit **66** generates a stopping signal S. Then, the stopping determination unit **66** generates the torque value T**2** as the final torque value T**2** for when the motor **15** and the output shaft **16** stop rotating.

Referring to FIG. **9**, when the hammer **19** strikes the anvil **20** before the output shaft **16** stops rotating, the impact pulse I after the stopping determination unit **66** generates the stopping signal S may be smaller than the impact pulse I immediately before the stopping determination unit **66** generates the stopping signal S. In such a case, the torque value before the output shaft **16** of the motor **15** stops is the maximum torque value measured by the torque measurement unit **65**. Thus, the final torque value, which is the torque value when the output shaft **16** of the motor **15** stops, is held at the torque value T**1**.

Referring to FIG. **10**, when the final torque value is held as the torque value T**1**, the stopping determination unit **66** generates the stopping unit S. Then, the torque value T**1** before the motor **15** and the output shaft **16** stop rotating is generated as the final torque value.

In this manner, in the present embodiment, the level of the impact pulse I after the stopping determination unit **66** generates the stopping signal S is compared with the torque value immediately before the stopping signal S is generated. The torque value is varied when the peak value of the impact pulse I is larger than the torque value immediately before the stopping signal S is generated. The torque value is maintained when the peak value of the impact pulse I is smaller than the torque value immediately before the stopping signal S is generated. In this manner, even when the impact pulse I is generated after the stopping signal S is generated, the final torque value provided from the stopping determination unit **66** is a torque value that reflects the impact pulse I. Thus, the accuracy of the final torque provided to the main body control circuit **30** may be increased.

In addition to the advantages of the impact rotation tool in the first embodiment, the impact rotation tool of the present embodiment has the following advantage.

(4) Even when an impact is produced after the stopping signal S is generated, the torque value before the stopping signal S is generated is compared with the peak value of the impact pulse I, and the comparison result is reflected to the final torque value. Thus, the final torque value is provided to the main body control circuit **30** with further accuracy.

Third Embodiment

A third embodiment of an impact rotation tool will now be described with reference to FIGS. **11** and **12**. The impact rotation tool of the third embodiment differs from that of the first embodiment in that two slip ring units are arranged on the main shaft **21**. The difference will now be described in detail.

Two slip ring units are arranged along the axial direction of the main shaft **21**. The first slip ring unit is connected to the stopping determination unit **66** of the rotation unit control circuit **200**. The stopping determination unit **66** provides the stopping signal S to the main body control circuit **30** via the first slip ring unit. The second slip ring is connected to the torque measurement unit **65** of the rotation unit control circuit **200**. The torque measurement unit **65** provides the torque value to the main body control circuit **30** via the second slip ring unit.

Referring to FIG. **11**, the stopping signal S from the stopping determination unit **66** is provided to the main body control circuit **30** via the first slip ring unit, and the output includes noise N from the first slip ring unit. The noise N produced from the first slip ring unit is of a level that does not affect the stopping signal S provided to the main body control circuit **30**. Thus, the motor **15** may be stopped when the stopping determination unit **66** generates the stopping signal S, that is, when the torque applied to the main shaft **21** reaches the target torque To.

In this manner, the slip ring unit that provides the stopping signal S to the main body control circuit **30** differs from the slip ring unit that provides the torque value to the main body control circuit **30**. Thus, the main body control circuit **30** is provided with the torque value even when provided with the stopping signal S. Thus, for example, the torque value is continuously provided to the main body control circuit from when the impact rotation tool **11** starts tightening a screw or the like to when the tightening is completed.

Referring to FIG. **12**, the torque value provided to the main body control circuit **30** includes noise N produced from the second slip ring unit. Thus, although there is an error between the provide signal and the torque value measured by the torque measurement unit **65**, the history of the torque value is recorded to the recording unit **203**. As a result, in addition to the final torque value that is the torque value when the tightening ends, the torque value from when screw tightening starts to when the tightening ends is recorded to the recording unit **203** as a torque curve. This allows for the user to obtain information related to the torque from when the impact rotation tool **11** starts operating to when it stops operating.

In addition to the advantages of the impact rotation tool in the first embodiment, the impact rotation tool of the present embodiment has the following advantage.

(5) The stopping signal S from the stopping determination unit **66** and the torque value from the torque measurement unit **65** is provided to the main body control circuit **30** through different slip ring units. Thus, while increasing the accuracy of the determination for stopping the motor **15** with the stopping signal, torque information may be obtained from when a task starts to when the task ends.

Fourth Embodiment

A fourth embodiment of an impact rotation tool will now be described with reference to FIGS. **13** and **14**. The impact rotation tool of the fourth embodiment differs from that of the third embodiment in that noise is eliminated from the torque value provided to the main body control circuit **30**. The difference will now be described in detail.

As described above, the impact sensor **201** is arranged on the main body housing **12** of the impact rotation tool **11** to detect the impact of the hammer **19**.

Referring to FIG. **13**, the impact sensor **201** generates an impact detection pulse as a predetermined voltage signal whenever detecting an impact. The impact sensor **201** generates an impact detection pulse when detecting, for example, stress that is greater than a predetermined value. As shown in FIG. **13**, the impact sensor **201** may generate an impact detection pulse for a longer time when the impact is larger. Alternatively, the impact sensor **201** may generate an impact detection pulse for a fixed time regardless of the level of the impact.

The impact sensor **201** provides the impact detector **202** with an impact detection pulse. When the impact detector **202** receives the impact detection pulse, the impact detector **202** provides the main body control circuit with a prohibition signal that prohibits the updating of the torque value received via the second slip ring unit for a predetermined period t. As shown in FIG. **13**, the impact detector **202** may be configured to set a longer predetermined period t as the output time of the impact detection pulse becomes longer. Alternatively, the impact detector **202** may be configured to set a fixed predetermined time t regardless of the output time of the impact detection pulse.

As shown in FIG. **14**, in the main body control circuit **30**, the updating of the torque value provided via the second slip ring unit is prohibited during the predetermined period t. That is, the provided torque value is ignored. As a result, the second slip ring unit provides the main body control circuit **30** with a torque value from which noise is eliminated. In a configuration in which the main body control circuit **30** updates the torque value regardless of the produced impact, the torque value received by the main body control circuit **30** includes noise N as shown in FIG. **12**.

In addition to the advantages of the impact rotation tool in the third embodiment, the impact rotation tool of the present embodiment has the following advantage.

(6) The main body control circuit **30** does not update the torque value until the predetermined period t elapses from when an impact is detected. This allows for the elimination of noise N from the torque value received by the main body control circuit **30**.

Fifth Embodiment

A fifth embodiment of an impact rotation tool will now be described with reference to FIGS. **15** and **16**. The impact rotation tool of the fifth embodiment differs from that of the first embodiment in that the torque value and the stopping signal S are simultaneously provided via the slip ring unit **27**. The difference will now be described in detail.

In the present embodiment, the torque value provided to the stopping determination unit **66** from the torque measurement unit **65** is constantly provided to the main body control circuit **30** via the stopping determination unit **66** and the slip ring unit **27**. Further, the stopping signal S generated by the stopping determination unit **66** is provided to the main body control circuit **30** via the slip ring unit **27**.

Referring to FIG. **15**, in the voltage signal generated by the rotation unit control circuit **200**, the torque value and the stopping signal S are overlapped with each other.

Referring to FIG. **16**, in the voltage signal received by the main body control circuit **30** via the slip ring unit **27**, the torque value, the stopping signal S, and noise N resulting from impact are overlapped with one another.

When the voltage level of the stopping signal S rises, that is, when the stopping signal S has a logical value of "1," the voltage is set to be sufficiently larger than the maximum torque value expected for the impact rotation tool **11**. Thus, even when the torque value and the stopping signal S are overlapped in the voltage signal received by the main body control circuit **30**, the motor control unit **64** does not mistake the torque value as the stopping signal S.

In addition to the advantages of the impact rotation tool in the fifth embodiment, the impact rotation tool of the present embodiment has the following advantage.

(7) The output of the torque measurement unit **65** is continuously provided to the main body control circuit, and the output of the torque measurement unit **65** and the output of the stopping determination unit **66** are provided to the main body control circuit **30** via the single slip ring unit **27**, namely, the four slip rings. Thus, without increasing the number of components forming the impact rotation tool **11**, the torque value may be obtained from when a task starts to when the task ends while increasing the stopping determination accuracy for the motor **15**.

Sixth Embodiment

Referring to FIGS. **17** and **18**, a sixth embodiment of an impact rotation tool will now be described. The impact rotation tool of the sixth embodiment differs from that of the first embodiment in the mechanism that inputs and outputs signals between the rotating system and the stationary system. The difference will now be described in detail.

Referring to FIGS. **17**A and **17**B, the impact force generation unit **17** includes the deceleration mechanism **18**, which is formed by a planetary gear mechanism, the hammer **19**, and the anvil **20**. The hammer **19** is supported by the drive shaft **22** urged toward the anvil **20** by the coil spring **24**. The torque sensor **26**, which is arranged on the main shaft **21**, rotates together with the anvil **20** and the main shaft **21** and generates a signal corresponding to the torque applied to the main shaft **21**.

When the motor **15** rotates the drive shaft **22**, steel balls **77** rotate the hammer **19** integrally with the drive shaft **22**. The anvil **20**, which is in contact with the hammer **19**, also rotates integrally with the drive shaft. When, for example, a screw is tightened, the load applied to the distal tool on the chuck **13***a* increases to an extent that the rotation of the distal tool cannot be maintained with the torque increased by the deceleration mechanism **18**. This rotates the hammer **19** relative to the anvil **20**, and moves the hammer **19** toward the rear, which is toward the deceleration mechanism **18**, in the axial direction of the drive shaft **22** against the urging force of the coil spring **24** together with the steel balls **77**. When the rearward movement of the hammer **19** separates the hammer **19** from the anvil **20**, the coil spring moves the rotating hammer **19** toward the front and strikes the anvil **20** with the hammer. Rotation torque produced by the impact of the hammer **19** is applied to the main shaft **21**.

A plurality of (for example, four) light transmission units **81** are arranged on the outer surface of the main shaft **21** at predetermined intervals in the circumferential direction. Each light transmission unit **81** is formed by, for example, a light-emitting diode. A light receiving unit **82** is arranged on the inner surface of the barrel **13** separated from the light transmission units **81**. That is, the light receiving unit **82** is arranged on the inner surface of the barrel **13** so that the light receiving unit **82** may oppose any one of the light transmission units **81** in a non-contact state. In this manner, the light receiving unit **82** does not contact the light transmission units **81** and is arranged on a mounting portion that does not rotate with the drive shaft **22**. The light receiving unit **82** is formed by, for example, a photodiode. Although four light transmission units **81** are arranged on the main shaft **21**, the number of light transmission units **81** may be three or less or four or greater as long as light may be received from one of the light transmission units **81** regardless of the rotational angle of the main shaft **21**.

The electrical configuration of the impact rotation tool **11** in the present embodiment is basically the same as that of the impact rotation tool in the first embodiment except for the light transmission units **81** and the light receiving unit **82**.

More specifically, when a stopping signal, which is the output of the stopping determination unit **66** shown in FIG. **3**, has a logical output of "1," the light transmission units **81** rotating integrally with the main shaft **21** are illuminated, and the light of the light transmission units **81** is received by the light receiving unit **82** as a stopping signal that is an instruction for stopping the operation of the motor **15**. When the stopping signal, which is the output of the stopping determination unit **66**, is "0," the light transmission units **81** are not illuminated. Thus, the light receiving unit **82** does not receive light.

In the present embodiment, under a non-contact state, the output from the stopping determination unit **66** is provided from the main shaft **21**, which forms the rotating system, to the barrel **13**, which forms the stationary system. Thus, in comparison to when a signal is provided from the stopping determination unit **66** in a contact state like the slip ring unit **27**, noise resulting from an impact does not easily become contained in the output of the stopping determination unit **66**.

Referring to FIG. **18**, after the stopping signal S is provided from the rotation unit control circuit **200**, the rotation of the motor **15** is stopped to stop rotating the main shaft **21** and the distal tool. Then, the torque value of the torque measurement unit **65** is provided from the rotation unit control circuit **200** to the main body control circuit **30** as a digital signal indicating a count value of pulses, that is, the final torque value T**1**. The final torque value T**1** is then recorded to the recording unit **203**.

In addition to the advantages of the impact rotation tool in the sixth embodiment, the impact rotation tool of the present embodiment has the following advantage.

(8) The stopping signal generated by the stopping determination unit **66** based on the signal of the torque sensor **26** may be transmitted in a non-contact state through optical communication from the light transmission units **81** to the light receiving unit **82**. Thus, noise resulting from an impact

does not easily become contained in the stopping signal. This increases the stopping determination accuracy for the motor **15**.

It should be apparent to those skilled in the art that the present invention may be embodied in many other specific forms without departing from the spirit or scope of the invention. Particularly, it should be understood that the present invention may be embodied in the following forms.

In the main body control circuit **30**, the signal line that provides the rotation unit control circuit **200** with a set torque value may be omitted. In this case, the set torque value is provided to the rotation unit control circuit **200** through the signal line that outputs signals from the rotation unit control circuit **200**. This allows for the number of wire systems connected via the slip ring unit **27** to be decreased from four to three.

The stopping of the motor **15** and the output shaft **16** is determined by the rotation speed detector **34** that detects the rotation speed of the motor **15**. Instead, for example, a rotation sensor may be arranged on a rotation shaft such as the main shaft **21** or the drive shaft **22**, and the output of the rotation sensor may be used to determine the stopping of the motor **15** and the output shaft **16**.

The rotation speed of the motor **15** after the stopping signal is generated does not have to be directly detected by the speed detector **34**. For example, an estimation circuit may be used to estimate changes in the rotation speed of the motor **15** after the stopping signal is generated. When the rotation speed estimated by the estimation circuit is "0," it may be determined that the rotation of the motor **15** has stopped. That is, the rotation speed output unit that generates a signal corresponding to the rotation speed of the drive source may be a circuit that detects the rotation speed of the motor **15** and outputs the detection result. Alternatively, the rotation speed output unit may be a circuit that estimates the rotation speed of the motor **15** and outputs the estimation result.

As the rotation speed of the motor **15** decreases, the noise produced by an impact becomes smaller. When the rotation speed of the motor **15** is less than or equal to a threshold, the rotation unit control circuit **200** computes a final torque value, and a final torque value may be provided from the rotation unit control circuit **200** to the main body control circuit **30**. In this configuration, the final torque value provided to the main body control circuit **30** becomes further accurate.

Instead of providing the final torque value after stopping the rotation of the motor **15** and the output shaft **16**, the final torque value may be provided from the rotation unit control circuit **200** to the main body control circuit **30** after a predetermined period elapses from when the stopping signal is provided from the stopping determination unit **66**.

In the embodiments other than the sixth embodiment, as shown in FIG. **18**, the final torque value T**1** provided from the control circuit **200** may be a digital signal indicated as a count value of a plurality of pulses. In this case, the torque measurement unit **65** may be formed by a processing circuit such as an A/D converter that converts the signal generated by the torque sensor **26** to a digital signal indicating a torque value and provides the torque value digital signal to the stopping determination unit **66**.

The main body control circuit **30** is provided with the torque value of the torque measurement unit **65**. However, a signal corresponding to the torque provided from the torque sensor **26** may be provided to the main body control circuit **30**.

The member on which the torque sensor **26** is arranged is not limited to the main shaft **21** and may be a member that allows for the torque sensor **26** to detect the torque applied to the main shaft **21**, such as the drive shaft **22**, the anvil **20**, and the hammer **19**.

In the impact rotation tools **11** of the second embodiment and the fifth embodiment, the output of the torque value from the rotation unit control circuit **200** does not have to be constantly performed and may be intermittently performed.

In the first embodiment, the predetermined driving state of the motor **15**, which is the drive source, is the stopped state but may be a decelerated state that reduces the rotation speed of the motor **15**. In this case, for example, a deceleration initiation torque value is set to be smaller than the target torque To by a predetermined value, and a control for decelerating the rotation of the motor **15** may be performed when the torque value reaches the deceleration initiation torque value. Further, a control for stopping the motor **15** may be performed after the motor **15** is driven in the decelerated state for a predetermined period. The predetermined driving state of the motor **15** may also be an accelerated state that increases the rotation speed of the motor **15**. In this case, to additionally tighten a screw or the like, when the torque value reaches a predetermined torque value, the motor **15** may be accelerated to a higher rotation speed until the main shaft **21** is rotated by a predetermined rotation amount or until the torque value reaches an additional tightening target torque value.

The third and fourth embodiments use two slip ring units. Instead of using two slip ring units in the third and fourth embodiments, the single slip ring unit **27** of the first embodiment may include an additional slip ring, that is, a total of five slip rings. By connecting the stopping determination unit **66** and the torque measurement unit **65** to different slip rings, the stopping signal and the torque value may be separately provided. This obtains the same advantages as the third and fourth embodiments.

As shown in FIGS. **19**A and **19**B, in the sixth embodiment, a light transfer unit **85** that transmits light from a light transmission unit **81** to the light receiving unit **82** may be arranged at the outer side of the main shaft **21**. In the example of FIG. **19**, even though there is only one light transmission unit **81**, the light transfer unit **85** allows for the light from the light transmission unit **81** to be received by the light receiving unit **82**. The light transfer unit **85** may be of a reflective type as shown in FIG. **19**A or a light guide type as shown in FIG. **19**B.

In the light transfer unit **85** of the reflective type shown in FIG. **19**A, for example, a metal tube **83** is arranged around the main shaft **21** without contacting the main shaft **21** and the light transmission unit **81**. The metal tube **83** is concentric with the main shaft **21**. The tube **83** includes an inner surface defining a mirror surface **83***a*, and the main shaft **21** includes an outer surface defining a mirror surface **21***a*. The tube **83** includes a light emission hole **83***b* at a position opposing the light receiving unit **82**. The light from the light transmission unit **81** is, for example, alternatively reflected by the mirror surface **83***a* and the mirror surface **21***a* and advanced in the circumferential direction between the main shaft **21** and the tube **83**. Then, the light is emitted from the light emission hole **83***b* and received by the light receiving unit **82**.

In the light transfer unit **85** of the light guide type shown in FIG. **19**B, the single light transmission unit **81** is arranged on the outer surface of the main shaft **21** so that the light is emitted from the light transmission unit **81** in a sideward direction that is the tangential direction of the outer surface of the main shaft **21**. Further, a tubular light guide plate **84** is arranged on the main shaft **21** concentric with the main shaft **21**. A circumferential end of the light guide plate **84** is opposed to the light emission portion of the light transmission unit **81**, and the light guide plate **84** is in contact with the outer surface of the main shaft **21**. Further, the light emitted from the light transmission unit **81** is propagated in the circumferential direction in the tubular light guide plate **84**. This illuminates the entire outer surface of the light guide plate with light having a predetermined brightness or greater, and the light of the light guide plate **84** is received by the light receiving unit.

In these structures, the light from the single light transmission unit **81** may be received by the light receiving unit **82**. Thus, in comparison with the structure of the sixth embodiment, the light transfer unit **85** is added. However, three light transmission units **81** and light emission control wires may be omitted in the example shown in FIG. **17**. This simplifies the structure and reduces the power consumption of the light transmission unit **81**.

The motor may be a DC motor or AC motor other than a brushed motor or brushless motor.

The drive source of the impact rotation tool **11** is not limited to a motor and may be, for example, a solenoid. Further, the drive source does not have to be an electric drive source like a motor or a solenoid and may be a hydraulic drive source. In this case, the drive source may be, for example, a hydraulic motor of which output rotation is provided to the impact force generation unit **17**. Alternatively, the drive source may be a hydraulic cylinder, and pulsed impact force may be generated with the hydraulic force of the impact force generation unit **17**. Further, the drive source may be of a pneumatic type.

The impact rotation tool **11** may be an AC impact rotation tool that is non-chargeable.

In addition to an impact driver and an impact wrench, the impact rotation tool **11** may be a hammer drill, a circular saw, a jigsaw, a vibration driver, a grinder, a nail gun, or the like. In these cases, an impact force generation unit is used to generate an impact force and rotate a shaft when a large load is applied to the shaft.

The present examples and embodiments are to be considered as illustrative and not restrictive, and the invention is not to be limited to the details given herein, but may be modified within the scope and equivalence of the appended claims.

The invention claimed is:

1. An impact rotation tool comprising:

a drive source that generates power;

an impact force generation unit that generates impact force by changing the power generated by the drive source to pulsed torque;

a shaft that transmits the pulsed torque to a distal tool with the generated impact force;

a torque detector that generates a signal corresponding to the torque applied to the shaft;

a determination unit that determines whether or not a torque value obtained from a signal corresponding to the torque has reached a predetermined torque value; and

a control unit that controls the drive source to a predetermined driving state when the determination unit determines that the torque value has reached the predetermined torque value,

wherein a rotation unit control circuit including the determination unit is arranged on the shaft, and

the impact rotation tool further comprising a slip ring unit arranged between the torque detector and the control unit, wherein the slip ring unit transmits a signal from the torque detector to the control unit.

2. The impact rotation tool according to claim **1**, further comprising:

a rotation speed output unit that generates a signal corresponding to a rotation speed of the drive source; and

a torque measurement unit that obtains the torque value from the signal corresponding to the torque,

wherein the determination unit provides the control unit with the torque value obtained by the torque measurement unit when determining that the rotation speed is less than or equal to a threshold based on the signal corresponding to the rotation speed of the drive source generated by the rotation speed output unit.

3. The impact rotation tool according to claim **2**, wherein the determination unit constantly continues to provide the control unit with the torque value obtained by the torque measurement unit.

4. The impact rotation tool according to claim **3**, wherein the control unit ignores the torque value obtained by the torque measurement unit from when the impact force is generated to when a predetermined period elapses.

5. The impact rotation tool according to claim **2**, wherein the torque measurement unit constantly continues to provide the control unit with the signal corresponding to the torque.

6. The impact rotation tool according to claim **2**, wherein

the determination unit generates a stopping signal when determining that the torque value has reached the predetermined torque value, and

the determination unit provides the control unit with the stopping signal and the torque value, which is obtained from the torque measurement unit, using the same signal line.

7. The impact rotation tool according to claim **1**, wherein when the impact force generation unit generates the impact force after the determination unit determines that the torque value has reached the predetermined torque value, the determination unit provides the control unit with a torque value based on a comparison of the impact force generated before the determination and the impact force generated after the determination.

8. The impact rotation tool according to claim **7**, wherein

when the impact force generated before the determination is greater than the impact force generated after the determination, the determination unit provides the control unit with a torque value taken before the determination, and

when the impact force generated before the determination is less than the impact force generated after the determination, the determination unit provides the control unit with a torque value taken after the determination.

9. The impact rotation tool according to claim **1**, wherein the slip ring unit is arranged on a portion of the shaft between the impact force generation unit and the torque detector.

10. The impact rotation tool according to claim **1**, wherein the slip ring unit is arranged between the determination unit and the control unit, wherein the slip ring unit transmits a signal from the determination unit to the control unit.

11. The impact rotation tool according to claim **10**, wherein the slip ring unit is arranged on a portion of the shaft between the impact force generation unit and the determination unit.

12. The impact rotation tool according to claim **1**, further comprising:

a light transmission unit that rotates integrally with the shaft and generates light corresponding to a signal provided from the determination unit;

a light receiving unit that receives light from the light transmission unit; and

a mounting portion on which the light receiving unit is mounted, wherein the mounting portion does not contact the light transmission unit and is not rotated by rotation of the shaft.

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